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A Bibliometric Analysis of the Tea Quality Evaluation using Artificial Intelligence

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ABSTRACT: In this study, we have carried the bibliometric review of the “Tea quality evaluation using artificial intelligence”. Only the Scopus database is under consideration for this analysis. To coat all possible research approaches here we have generated the valid search queries which excludes irrelevant literature. The result analysis shows overall 602 useful papers are available on the tea quality evaluation out of which 12 papers are specifically on artificial taste perception of tea. This survey illustrates the emerging trend of quality evaluation and assurance (QEA) in tea industry and its importance. As the production of tea is huge, storage and aging of the tea are the effective factors which will harm tea industry business this kind of analysis and further research is required in this field. The global standards for such electronic artificial systems in tea industry are highly sensitive, biased and inconsistent. The primary analysis of search results is derived from Scopus database directly and some other tools have utilised for bibliometric analysis such as Microsoft Excel, VOSviewer, and ScienceScape.This survey discovered the contribution of various organizations, research authors, funding sponsors in the area of tea quality evaluation and artificial taste perception of tea.

Keywords: Tea analysis, E-tongue, E-nose, Artificial intelligence, Sensory evaluation, Bibliometric Analysis, Artificial taste perception.

1. INTRODUCTION

Modern generation is workaholic and survives on the readymade food and drink products. But at the same time it promotes the quality evaluation and assessment of food and beverages in concern with heath care. Both the producers and consumers of readymade food-drink products need the certification about product quality, safety and edibility. As food-drink is primary need, government agencies look after the welfare services. To support such kind of quality assurance; technology should be adopted.

Tea is the worldwide most popular hot beverage. In Ayurveda Tea is treated as medicine and due to its huge health benefits it is included in daily diet (Sen, G.,2013) India is the worldwide 2nd largest producer, consumer and exporter of the tea. As a leading tea industry worldwide it is important to showcase the unique tea attributes with automation and technology. In India British government promoted the tea farming and since then it is easily available throughout India. Tea is national drink of India as well.The 'Tea board of India' decides the farming, processing and marketing policies of tea in India. There are basically three main types of tea found in India; Green tea(non-fermented), Oolong tea (partly fermented), and Black tea (fermented).The scientific name of tea plant is Camellia sinensis. The leaves of this plant is processed and used as tea powder (Sen, G.,2013).

The processing of tea leaves should be appropriate for specific taste. To evaluate the quality of tea it is essential to use artificial intelligence (Hayashi, N., 2007, Bajec, M. R., 2008, Tozlu, B. H., 2018) as production of tea is vast in India, and now days the flavor verity is available in India with added natural or artificial flavor. So sometimes from consumer side it is required to verify tea taste early with all possible chemical evaluation (Li, Y., 2015, Singh, G., 2013).

This survey illustrates; for the agricultural commodity quality evaluation using artificial intelligence is the most challenging task. Common electronic sensors can be the part of processing, monitoring and marketing chain of the product but for the quality evaluation and assurance (QEA) of agricultural products; sensor technology (Tahara,Y., 2013, Roy, R. B., 2013) which can detect the basic attributes like its colour, smell and flavor have to be developed with artificial intelligence (Bhattacharyya, N.,2008) and machine learning techniques.

1.1 Bibliometric Study:

Bibliometric study is the statistical method to get the overview of the research area (Baviskar, D., 2020, Rathinam, S., 2019) .Bibliometry research is essential to understand the depth of the work done earlier in the selected research area. At initial level it will generate the brief view about the research scope and research gaps in the selected research field. It include peer review journal - conference articles, book, book chapters, funding agencies, patents and awards granted, location of the research publication with university affiliation (Patil, R. R., 2020, Gokhale, A., 2020). In short it generates research impact to assess the quality of research in terms of research gaps and scope of the research (Baviskar, D., 2020, Rathinam, S., 2019). This data will help lot to a researcher for the collaboration, research funding or guidance in the selected area. It will also help to get interdisciplinary work to know all possible approaches of research in the field to decide the strategy and methodology to be fallowed.

1.2 Bibliometric Research objectives of the Tea Quality Evaluation using Artificial Intelligence and Machine Learning Approach:

The bibliometric research on the Tea Quality Evaluation (Karakaya, D.,2020, Tozlu, B. H., 2018) using Artificial Intelligence and Machine Learning Approach can be used to get a better overview and

understanding about the scope and limitations of the given research area and it is fallowed with some objectives mentioned below (Baviskar, D., 2020, Rathinam, S., 2019).

· To find the total number of documents available from the standard repository
. To analyze and observe the proportional coverage of the related subject areas
. To know the published document types with exact count.
. To get information and analyze it for the sources of publication, year-wise research trends
. To recognize most contributing bodies in research, funding agencies and beneficiaries
. To identify the research authors and university affiliations with their research contribution
. To learn systematic approach to find research gaps from the historical records of the research and to learn to exclude the irrelevant material from the huge stack.

2. PRIMARY DATA COLLECTION

The research publications are of two types, one is subscription based which comes with pay charges and another is non subscription based which are freely available to researchers as open access articles. Industry sector makes them available to research and development (R&D) team as a study material primary data. Educational sectors, universities, educational organization provides library resources through offline and online media. Few year back journals were available in the hardcopy format in libraries but now days as internet is on tip; through online media any research scholar can access articles by registering himself individually or through organization. As like every book; the sources referred have mentioned at the backside of book with all details; any research article comes with references at the end. There are many global online scientific research repositories like Web of science, Scopus, Google scholar, IEEE explore, Research Gate, J-Gate, Science Direct (Baviskar, D., 2020, Rathinam, S., 2019).
In this bibliometric survey Scopus is used as the standard data repository to analyze the recent trends in Tea quality evaluation using artificial intelligence and machine learning (Nagtode, S. A., 2015, Podrażka, M., 2018). Scopus is big multidisciplinary database with abstracts and citations from peer reviewed journal, commercial journal,book, book chapters, patents, conference proceedings. With the help of Scopus online website, researcher can track, analyze and visualize the search results.

Section 2 is about query string generation with research keywords and primary data analysis.

2.1 Significant Keywords:

Keywords are the important words required to generate specific query. Keywords given are of two types; primary and secondary keywords. Primary keywords are the main keywords and secondary keywords are the additional searchdetails.

Table 1: Keywords selected for bibliometric survey on Artificial taste perception of Tea

Sr. No.	Primary Keywords	Secondary Keywords using AND	Secondary Keywords using OR	Total Publications found
a.	Tea	Quality, Evaluation	Nil	602
b.	“Artificial taste perception”	Tea	Nil	12

There are number of filters available in Scopus database; with the help of them we can easily search out related documents. The filters of Scopus database are- Open Access, Year, Author Name, Subject Area, Document Type, Publication Stage, Source Title, Keyword, Affiliation, Funding Sponsor, Country/Territory, Source Type, Language. We can limit search to or exclude the selection which we don't want to search specifically.

The following are the query strings generated by keywords with the help of filters for year and language selection:

a. TITLE-ABS-KEY (tea AND quality AND evaluation) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010))

b. TITLE-ABS-KEY (artificial AND taste AND perception AND of AND tea)

With query string a. the total number of publications found were 602 which are limited to English and from the year 2010 to 2021 whereas with query string b. the total publications found were 12 for the entire duration; again limited to English for the duration 2011 to 2020 only 10 documents were found.

2.2 Result of Initial inquiry string:

Scopus database is very huge database; proper keywords with filters have to be selected to find the required dataset (Baviskar, D., 2020, Rathinam, S., 2019). In Scopus "Analyze search results" tab is there; which will help you to generate the analysis for enrolled query string. Table 2 and Table 3 are showing the results of publication types and their respective count for the two strings mentioned in topic 2.1.

Table 2: Type of Publications available on "Tea quality evaluation" of string a

Publication Type	Publication count	Percentage
Article	489	81.23
Conference Paper	57	9.47
Review	31	5.15
Book Chapter	11	1.83
Conference Review	11	1.83
Erratum	1	0.17
Letter	1	0.17
Note	1	0.17
Total	602	100.00

Table 3: Type of Publications available on "Artificial taste perception of tea" of string b

Publication Type	Publication count	Percentage
Article	7	58.33
Conference Paper	5	41.67
Total	12	58.33

As given in Table 2; maximum contribution in publications on 'query string a' is of Article, conference papers, reviews and book chapters whereas Table 3 shows publications for 'string b' which are only articles and conference papers. Table 2 shows 602 publications are available in the overall research area; which indicates high researcher's interest which ultimately belongs to public interest. Table 3 is showing the selected string is under development so the publication count is least.

Table 4 data is generated in Scopus search window with the search 'string b' and exported in CSV form for the required details. Publications are arranged according to their citation score in descending manner (Baviskar, D., 2020, Rathinam, S., 2019). The title, type, and source of documents are mentioned with year and authors for top 12 related papers.

Table 4: Specific result of query string b with citation score

Sr. No.	Authors	Title	Year	Source title	Cited by	Document Type
1	Scharbert S., Hofmann T.	Molecular definition of black tea taste by means of quantitative studies, taste reconstitution, and omission experiments	2005	Journal of Agricultural and Food Chemistry	227	Article
2	Banerjee R., Chattopadhyay P., Tudu B., Bhattacharyya N., Bandyopadhyay R.	Artificial flavor perception of black tea using fusion of electronic nose and tongue response: A Bayesian statistical approach	2014	Journal of Food Engineering	46	Article
3	Ikeda G., Nagai H., Sagara Y.	Development of food kansei model and its application for designing tastes and flavors of green tea beverage	2004	Food Science and Technology Research	18	Article
4	Yu P., Low M.Y., Zhou W.	Development of a partial least squares-artificial neural network (PLS-ANN) hybrid model for the prediction of consumer liking scores of ready-to-drink green tea beverages	2018	Food Research International	11	Article

5	Banerjee R., Chattopadhyay P., Rani R., Tudu B., Bandyopadhyay R., Bhattacharyya N.	Discrimination of black tea using electronic nose and electronic tongue: A Bayesian classifier approach	2011	2011 International Conference on Recent Trends in Information Systems, ReTIS 2011 - Proceedings	5	Conference Paper
6	Majchrzak D., Ipsen A., Koenig J.	Sucrose-replacement by rebaudioside a in a model beverage	2015	Journal of Food Science and Technology	4	Article
7	Banerjee M.B., Roy R.B., Tudu B., Bandyopadhyay R., Bhattacharyya N.	Cross-perception fusion model of electronic nose and electronic tongue for black tea classification	2017	Communications in Computer and Information Science	3	Conference Paper
8	Ghosh A., Chatterjee T., Borah P.K., Sing D., Tudu B., Tamuly P., Bhattacharya N., Bandyopadhyay R.	Multi-frequency large amplitude pulse voltammetric electronic tongue to assess key compounds imparting the taste of briskness to finished black tea liquor	2015	ACM International Conference Proceeding Series	2	Conference Paper
9	Yang J.-E., Lee J.	Consumer perception and liking, and sensory characteristics of blended teas	2020	Food Science and Biotechnology	1	Article
10	Modak A., Banerjee R., Tudu B., Bandyopadhyay R., Bhattacharyya N.	Towards artificial flavor perception of black tea: An approach using fusion of electronic nose and electronic tongue responses with fuzzy ART classification technique	2015	ACM International Conference Proceeding Series	1	Conference Paper
11	Jose T.M., Priya A., Bhaskar A.	The effect of gymnemasylvestre on taste sensation	2018	Biomedicine (India)	0	Article

12	Ghosh A., Tudu B., Tamuly P., Bhattacharyya N., Bandyopadhyay R.	Improvement of quality perception for black CTC tea by means of an electronic tongue	2012	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	0	Conference Paper

The Table 4 indicates the article 'Molecular definition of black tea taste by means of quantitative studies, taste reconstitution, and omission experiments' is having high citation score about 227, and 'Artificial flavor perception of black tea using fusion of electronic nose and tongue response: A Bayesian statistical approach' is on 2nd position with 46 citations. Citation score indicates research utility of publication.

2.3 Statistical analysis of collected data:

It is important and highly demanding to observe the research trend for the selected query string (Baviskar, D., 2020, Rathinam, S., 2019). To analyze research interest one more important aspect is to find number of yearly publications for last decade. As many standard publications found on 'string a'; and is considered as matured research for current last decade; Table 5 shows exact publication count per year on 'string a'.

Table 5: Publication count for 'String a'

Year	No. of Publications
2021	10
2020	99
2019	81
2018	61
2017	49
2016	40
2015	48
2014	49
2013	43
2012	43
2011	37
2010	42
Total	602

For the data given in Table 5 the publications trend on tea quality evaluation has drawn in Figure 1. The linear trend line shows that the publications are having linear incremental growth in last decade. It also shows that in 2019 and 2020 the publication count is very high comparative to previous search results. This analysis confirms the high interest and demand of public in the selected research area.

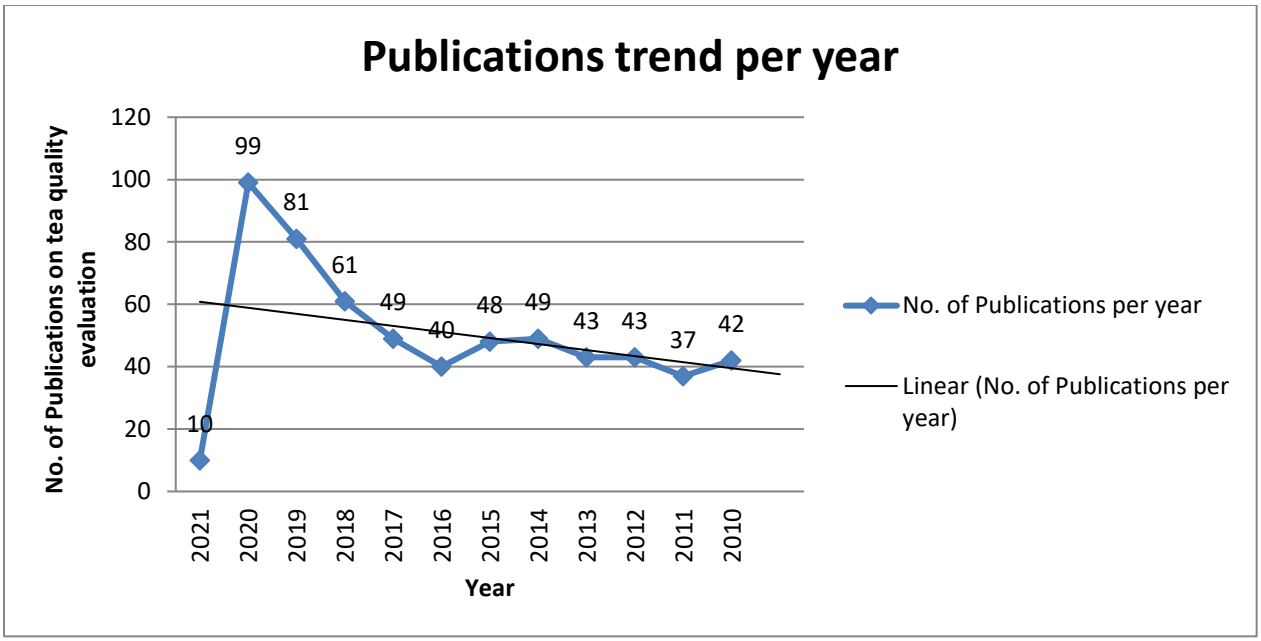

Figure 1: Year-wise Publication trend on tea quality evaluation.

Table 6 is the publications available on artificial taste perception of tea. As we know tea is common hot beverage which is daily consumed worldwide; market of tea is very huge, now days production processing and quality evaluation of tea (Zou,G., 2018, Saha, P., 2018) is dependent on artificial intelligence. Table 6 also concludes that the area-artificial taste perception of tea (Zou,G., 2018, Saha, P., 2018) is very much interesting but the actual workpublished in the areais very small comparatively in last decade. In tea producing countries like China, India; to decide marketing strategies of a tea, it is useful to demonstrate and prove the unique flavour, fragrance of tea species.

Table 6: Publication count for 'String b'

Year	No. of Publications
2020	1
2018	2
2017	1
2015	3
2014	1
2012	1
2011	1
Total	10

Day by day dependency on human is reducing as automation and artificial intelligence are growing gradually in each possible field. So table 6 is the decade analysis and shows poor publications count; in concern with the marketing aspect; attention and development is very much essential in this research area.

3. BIBLIOMETRIC ANALYSIS

At the initial stage of any research it is important to get overview of the selected research area, to collect available literature on the selected research area, to find gaps in research, to identify research problem, scope and limitations of selected research topic with the help of statistical tools. This kind of survey which will provide co-relevance and interrelationship amongst all elements of publications like keywords, authors, affiliations, citation score, and geographical visualization is very much required. Many free bibliometric tools are available for such kind of survey like Google sheet, Microsoft Excel, VOSviewer software.

3.1 Analysis based on geographic locations:

Scopus generates the standard database on the basis of country or territory (Baviskar, D., 2020, Rathinam, S., 2019). In this survey paper we are analysing two strings for bibliometric analysis; of which string a is for 'tea quality evaluation' generates following map using Google sheet. Two columns of Scopus database are required as input to the Google sheet; of which 1st is country and 2nd is publication count. Then by clicking on insert chart and selecting chart type 'map' we have received this world map with colour coating scale according to its maximum and minimum count of publications. It shows that China is with high publication about 220 and India is about 67 publications overall of the 602 total publications generated by the string a.

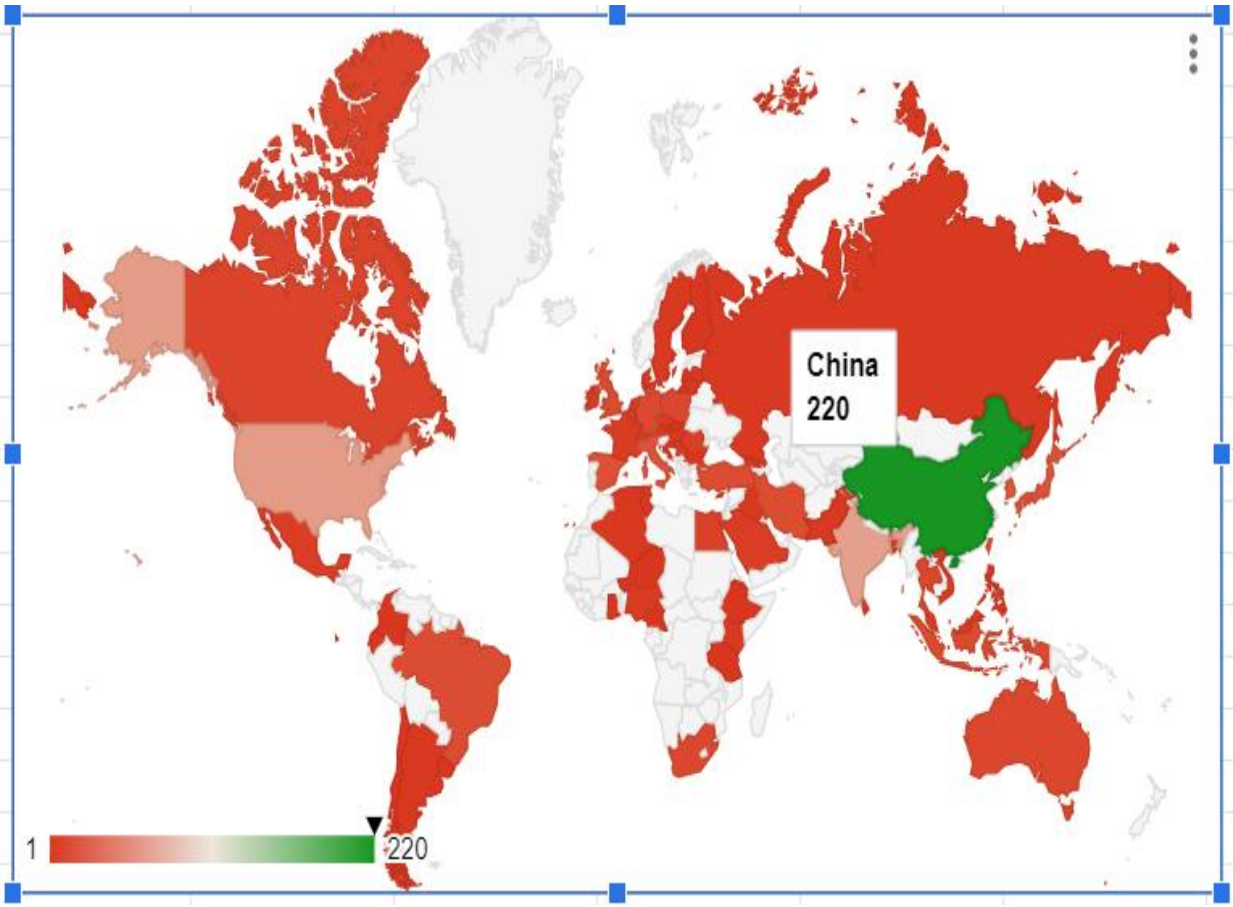

Figure 2: Country wise research work done on tea quality evaluation with China research count

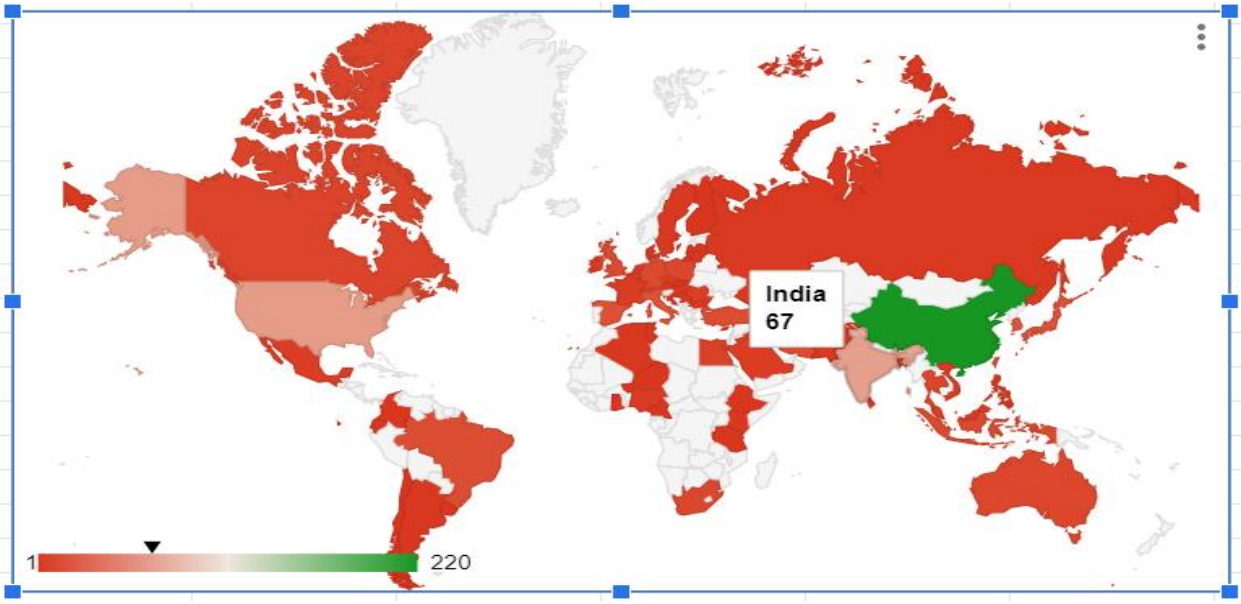

Figure 3: Country wise research work done on tea quality evaluation with India research count

Using Microsoft Excel tool the figure 4 had drawn for the top five countries which had published maximum research documents. It depicts the nation wise interest of selected query string in proportion with their publication count.

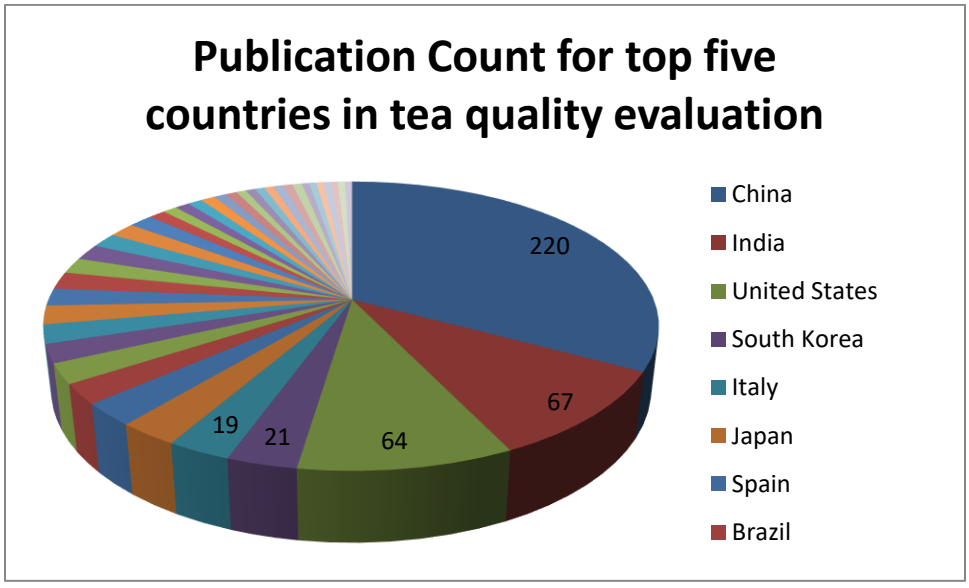

Figure 4: Top 5 countries with publication count

3.2 Keyword's Statistical analysis:

Keywords are the words for which search is initialised. Presence of keywords and their occurrence count indicates the probability of relevance of research article with those particular keywords. It basicallyshows co-

relevance and co-occurrence of keywords with the research articles. With the help of keywords it is easy to find the research publication; and very quickly as well (Baviskar, D., 2020).
The most probable keywords for query 'string a' and 'string b' have given in Table 7 and Table 8 respectively.

Table 7: Most probable Keywords found in all papers of string a

Keyword	**Occurred number of times**
Tea	212
Quality Control	190
Sensory Evaluation	58
Principal Component Analysis	56
Quality Evaluation	32
Comparative Study	31
Sensory Analysis	31
Electronic Nose	24
Quantitative analysis	24
Neural Networks	23
Taste	23
Sensory qualities	22
Electronic Tongues	15
Sensory Perception	14
Support Vector Machine	14
Electronic Tongue	13
Partial Least square regression	10

Table 8: Most probable Keywords found in all papers 'string b'

Keyword	**Occurred number of times**
Electronic Tongues	6
Sensory Perception	6
Artificial Intelligence	4
Black Tea	4
Electronic Nose	4
Electronic Tongue	4
Principal Component Analysis	4
Multisensor Data Fusion	3
Sensor Data Fusion	3
Artificial Perception	2

3.3 Network Analysis:

VOSviewer software is the tool which generates, visualises and explores map for the selected network attributes like Co-authorship, Co-occurrence, Citation, Bibliographic coupling and Co-citation (Baviskar, D., 2020). From any standard database like Web of Science, Scopus search results can be export in the form of CSV file for research publication details like Citation, Bibliographic information, Abstract, Keywords, Funding

details and this file can be given as the input directly to the VOSviewer software. For this survey the Scopus database with query 'string a' mentioned in section 2.1 CSV file is given as input.

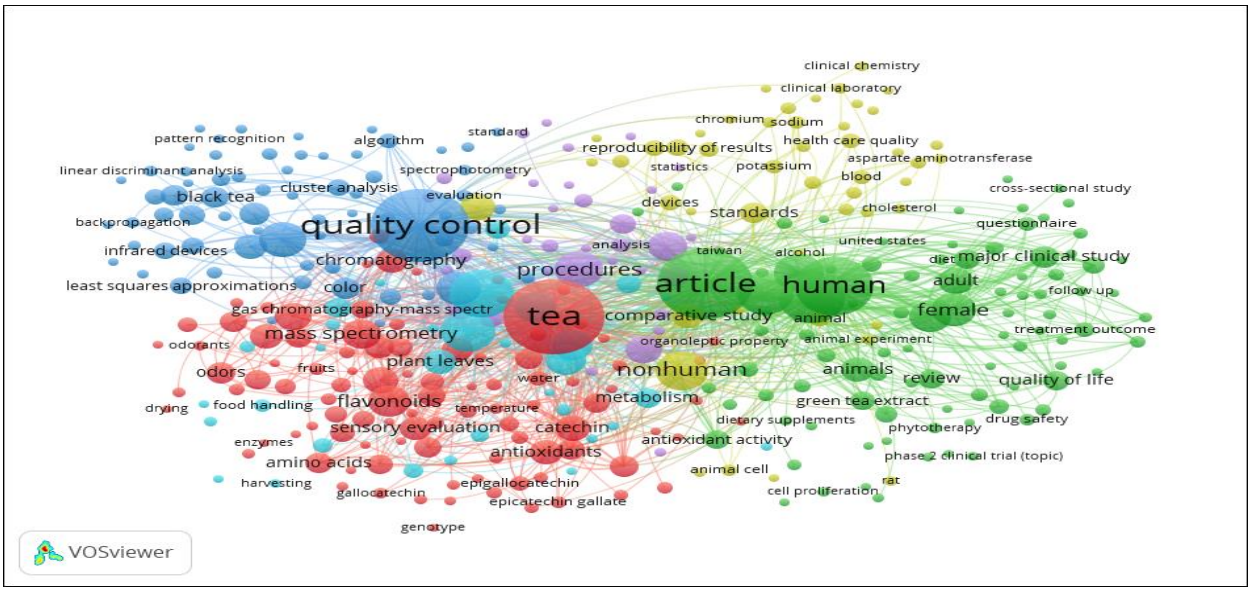

Figure 5: Keyword network visualization mapping

The input file is quickly analyzed by software for association strength with by default setting. In the software three types of maps had get created; the very 1st is network visualization. The size of circle and label indicates weight of the keyword; higher the weight of the keyword; larger is the size of label and circle. The distance between two keywords depicts the interrelation and relatedness of those two keywords with strength.

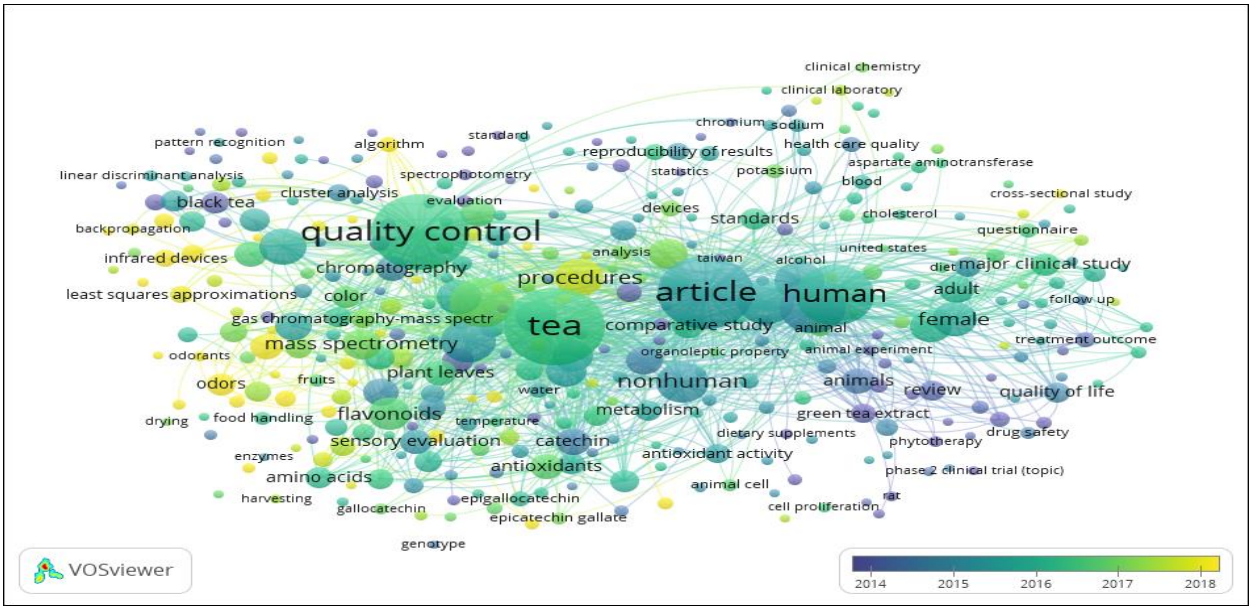

Figure 6: Keyword overlay visualization mapping with publication year scale

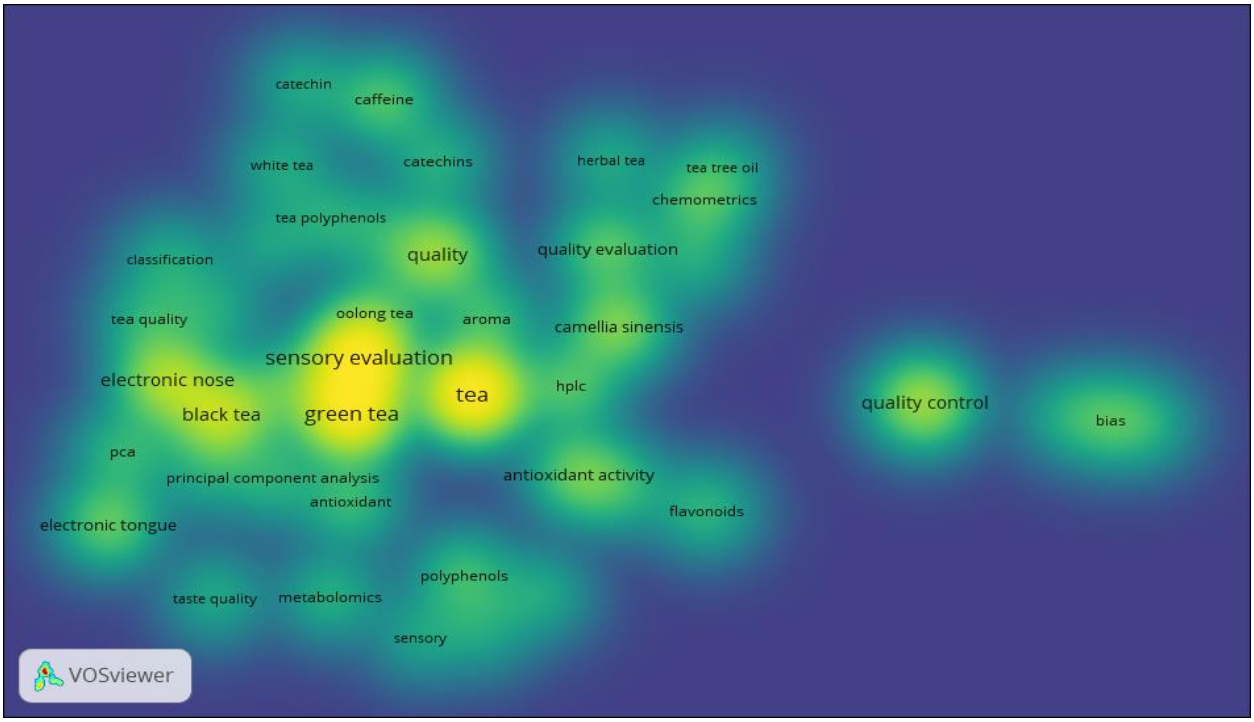

Figure 7: Density visualization of author keywords

The 2ndview is overlay visualization which generates mapping of keywords with average publication year scale indicated below. VOSviewer main panel 3rd view is about item and cluster density. The colour density of yellow colour of figure 7 defines the occurrence of author keyword.

3.4 Statistical analysis of research area:

The research area relevance is required to show as each topic can be globally explored with various research disciplines. Figure 8 is about the research area contribution in publications. So as shown in figure 8, for query 'string a' under the Engineering discipline 82 publications are available. Maximum contribution is of Agricultural and Biological Sciences discipline with 265 publications out of 602 publications.

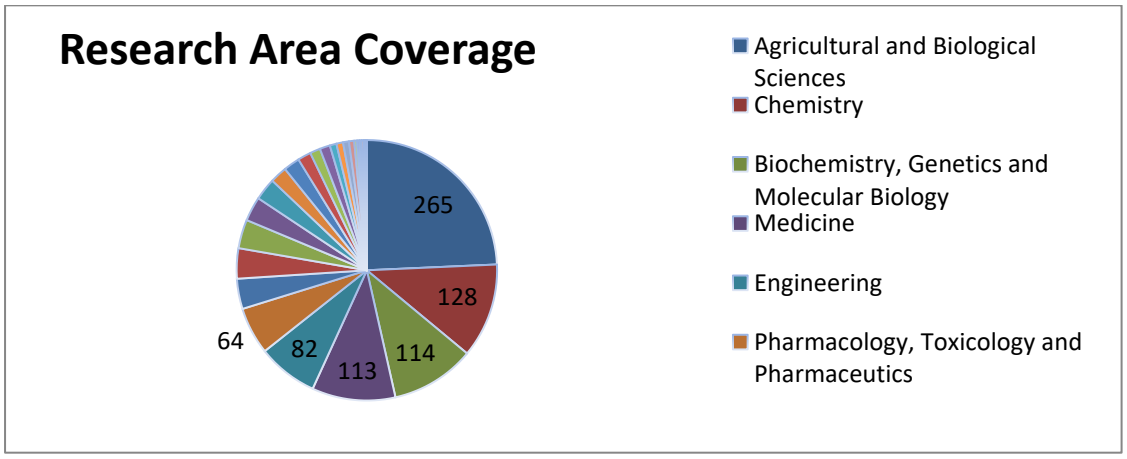

Figure 8: Research area branch wise coverage

3.5 Affiliations Statistical analysis:

The contribution of top ten organizations is given in figure 9 and is initialised for research query 'String a'. It is given that Chinese Academy of Agricultural Sciences has shown with maximum publications around 31. The data shows the high research interest of community belongs to China; and it is the country worldwide having 1st position in production and export of tea.

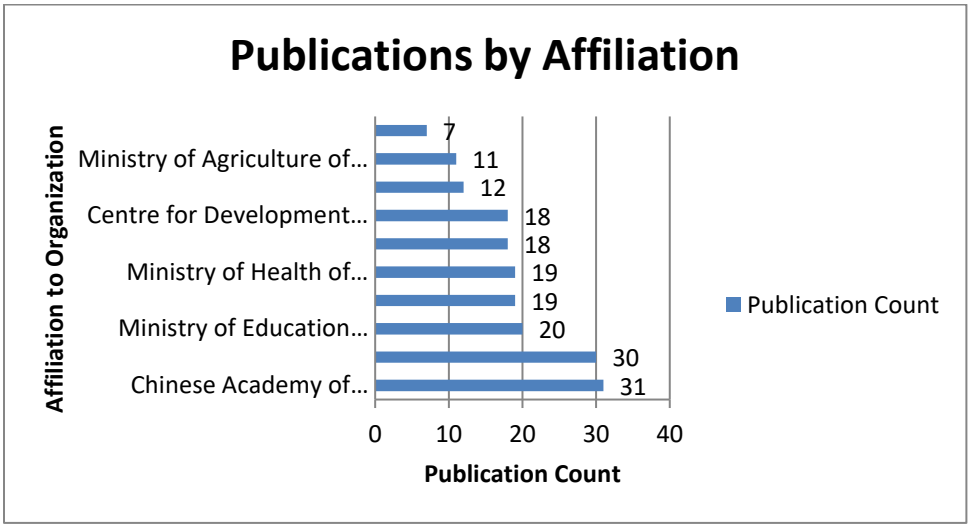

Figure 9: Top ten organizations with Publications in tea quality evaluation

3.6 Authors Statistical analysis:

Author is the writer of the publications, the below figure 10 indicates author wise contribution of publications for top ten authors. By knowing total publications count other researchers can refer all related papers.

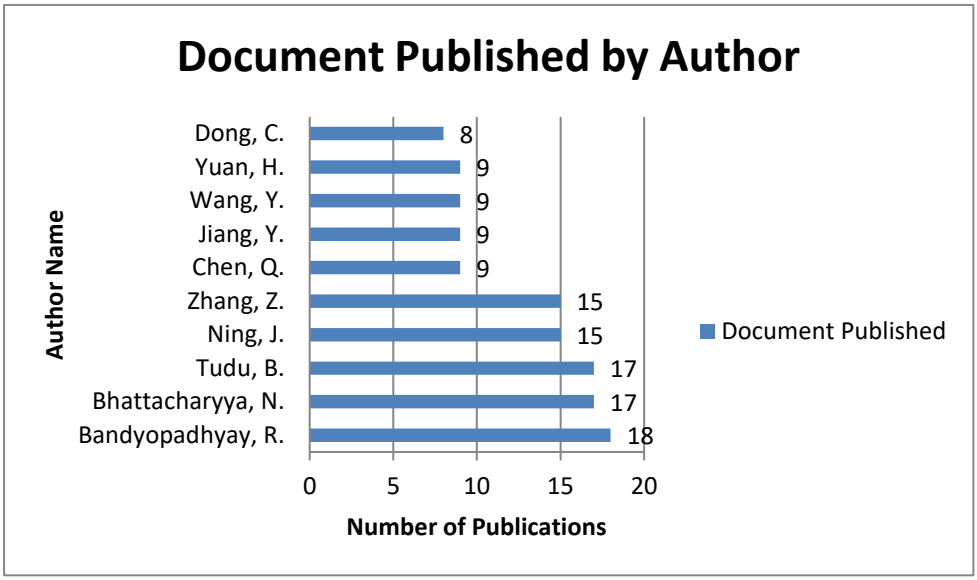

Figure 10: Top ten Authors with publications in tea quality evaluation

3.7 Citations statistical analysis:

Citations indicate the count by which the number of times research publications have referred and used. It is actually the utility factor of publications. Figure 11 is about publications citation score and had derived using VOSviewer software. The large size of label and circle indicates the citation score is higher. Links of map represents the inter-linkage of publications with their citations.

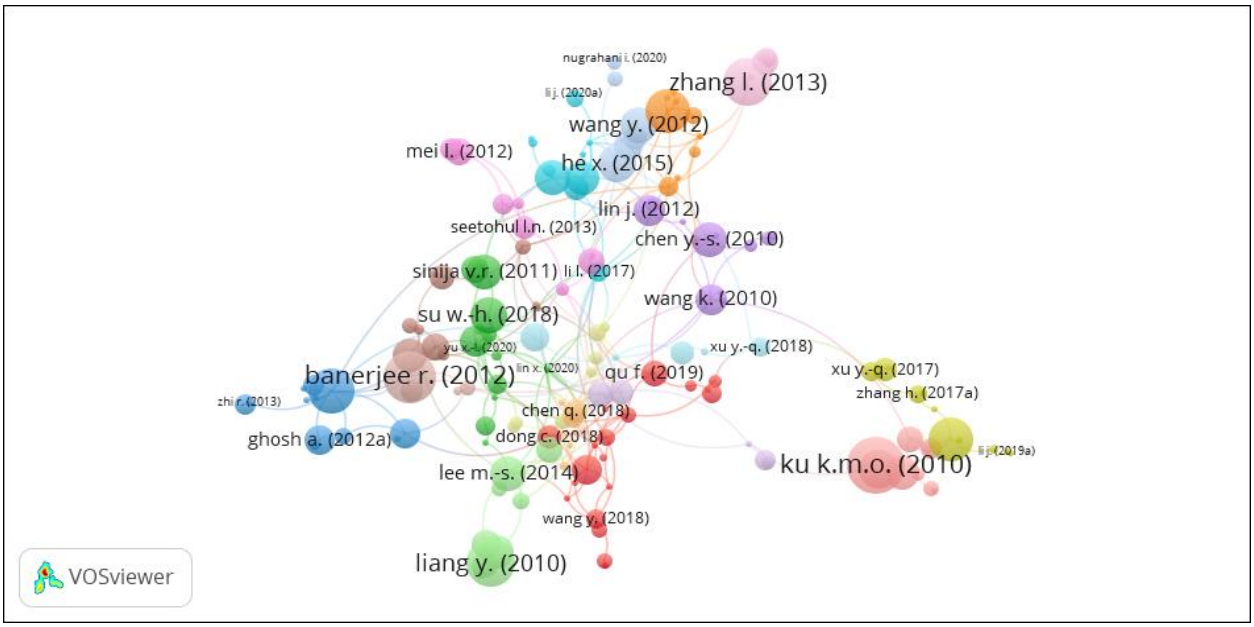

Figure 11: Publications map with citation score

3.8 Source titles statistical analysis:

The ScienceScape is the online tool which can analyze the Scopus and Web of Knowledge CSV file for publications details. It will provide Network generation for given database; visualize papers, keywords, journals over time. Figure 12 shows co-appearance of source titles and author keywords.

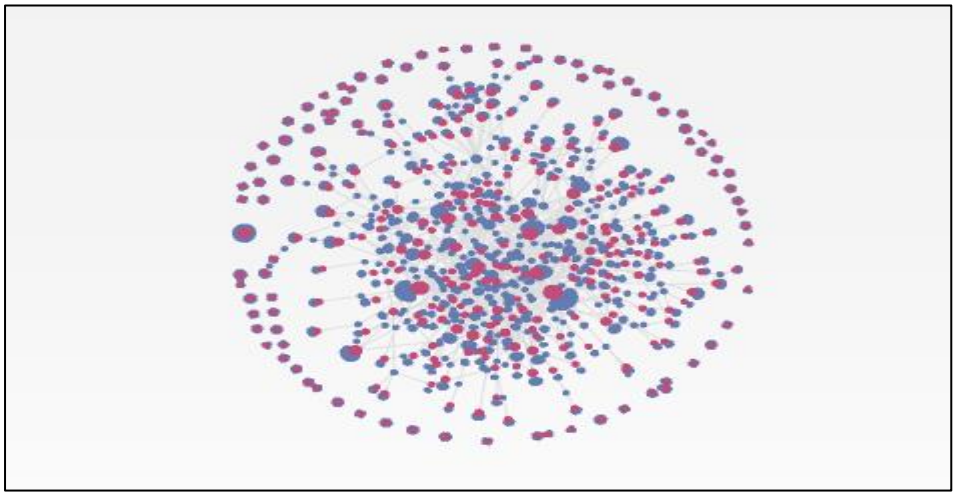

Figure 12: Network cluster for co-appearance of source titles and author keywords
Source: https://medialab.github.io/sciencescape/scopus2net/

For this visualization the Scopus CSV file for tea quality evaluation is given as input and network generation is selected for Source Titles and Author keywords coappearing in the same paper. Nodes of two colours are around 2332 which indicate Titles and Author keywords and edges are 2689 which shows the inter-linking or co appearance. The filter is applied for disconnected nodes and result of which is 56 nodes have removed from the above network as they are disconnected.

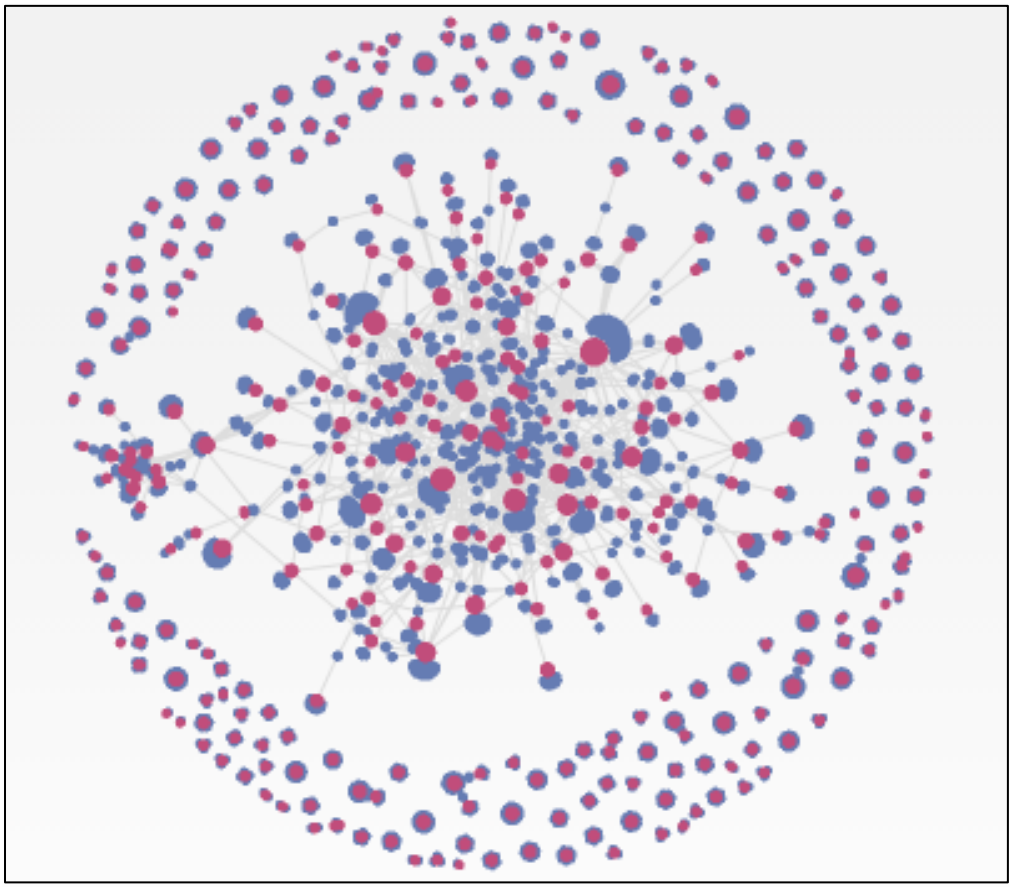

Figure 13: Network cluster for co-appearance of authors and source titles
Source: https://medialab.github.io/sciencescape/scopus2net/

Figure 13 depicts the network cluster for co-appearance of authors and source titles. The two different colours belong to authors and source titles. The edges show association between them. Total 2716 nodes and 2975 edges were found with co-appearance of authors and source titles filter is applied for disconnected nodes but report indicates there is no such disconnected node present in the network for co-appearance of authors and source titles.

3.9 Funding Sponsors statistical analysis:

Figure 14 shows the statistical graph between Sponsors and sponsored publications. The National Natural Science Foundation had sponsored maximum publications around 62. The information about top ten sponsors with publication count is mentioned in figure 14. This kind of data is useful to find out funding agencies and related collaborations. For high end research which is having social approach; the fund is the initial requirement. There are some agencies which will provide incubation, foundation for such research ideas which will be helpful in future for society welfare.

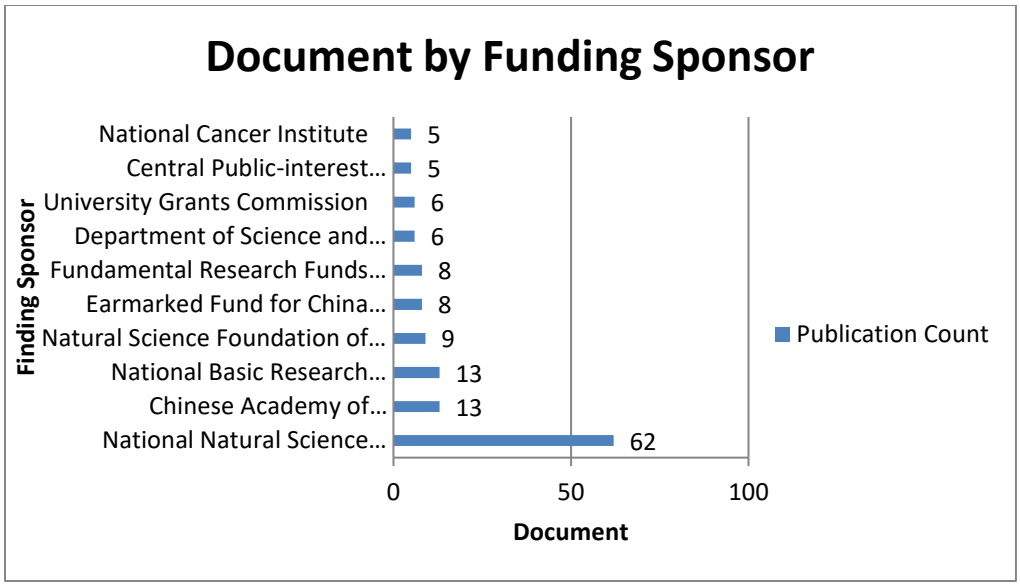

Figure 14: Top ten funding sponsor with publications

3.10 A-K-J Sankey Analysis:

The A-K-J Sankey Analysis is done with the help of ScienceScape where A stands for Author, K stands for Keyword and J stands for Journal.

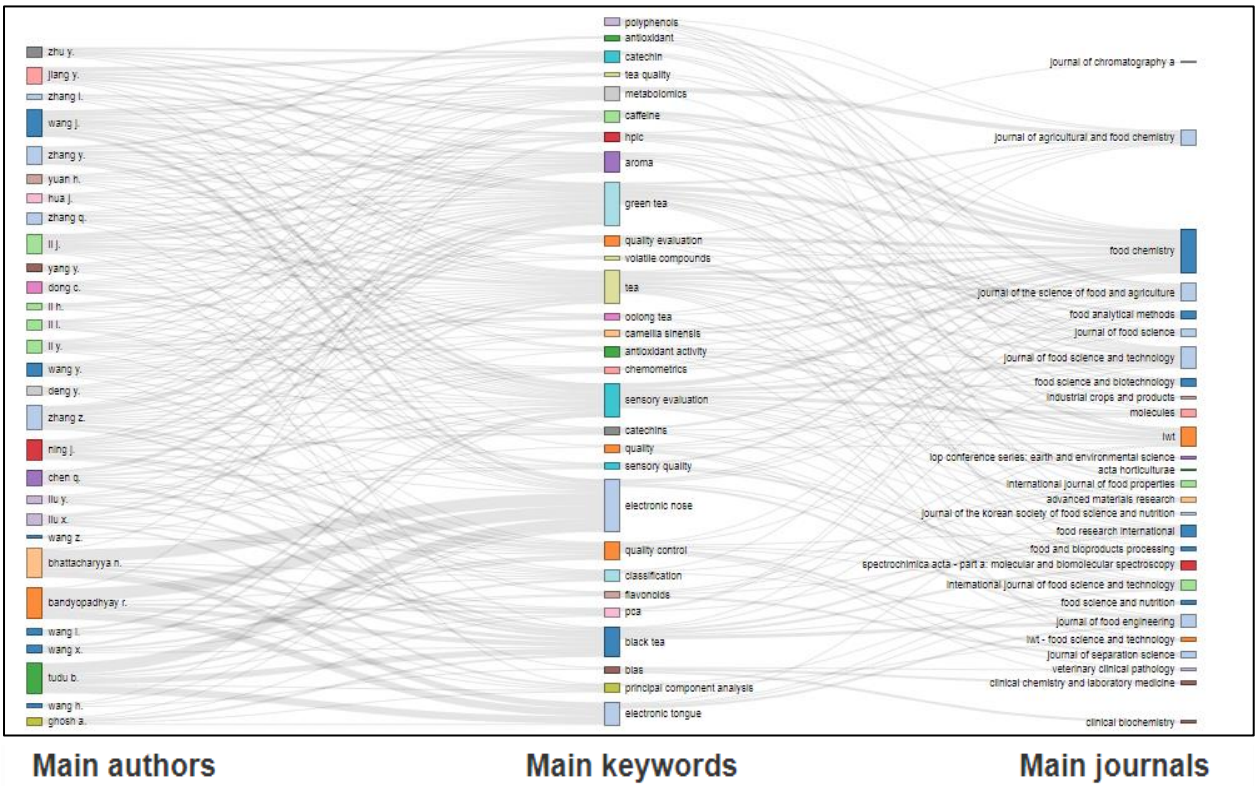

Figure 15: A-K-J Sankey Analysis of tea quality evaluation

Source:https://medialab.github.io/sciencescape/scopus_mostCitedPapersProfile/

The mapping between them has shown in figure 15. The CSV file derived from Scopus or Web of Knowledge is given as input to this A-K-J Sankey tab. The figure 15 describes the dynamic and complex relationship between the Author, Keyword and Journal. Below this mapping the actual online count will get displayed which shows correlation between them (Baviskar, D., 2020).

3.11 Analysis of Bibliographic coupling for research documents:

The mapping of bibliographic coupling with sources is given in below analysis using VOSviewer software. The number of total sources is 364. The minimum number of documents of a source is selected to 5. With this clause 18 sources meet will map and the mapping is shown in below figure 16.The size of the circle and label indicates the strength of the source. If size is higher the number of related documents is more in that source.

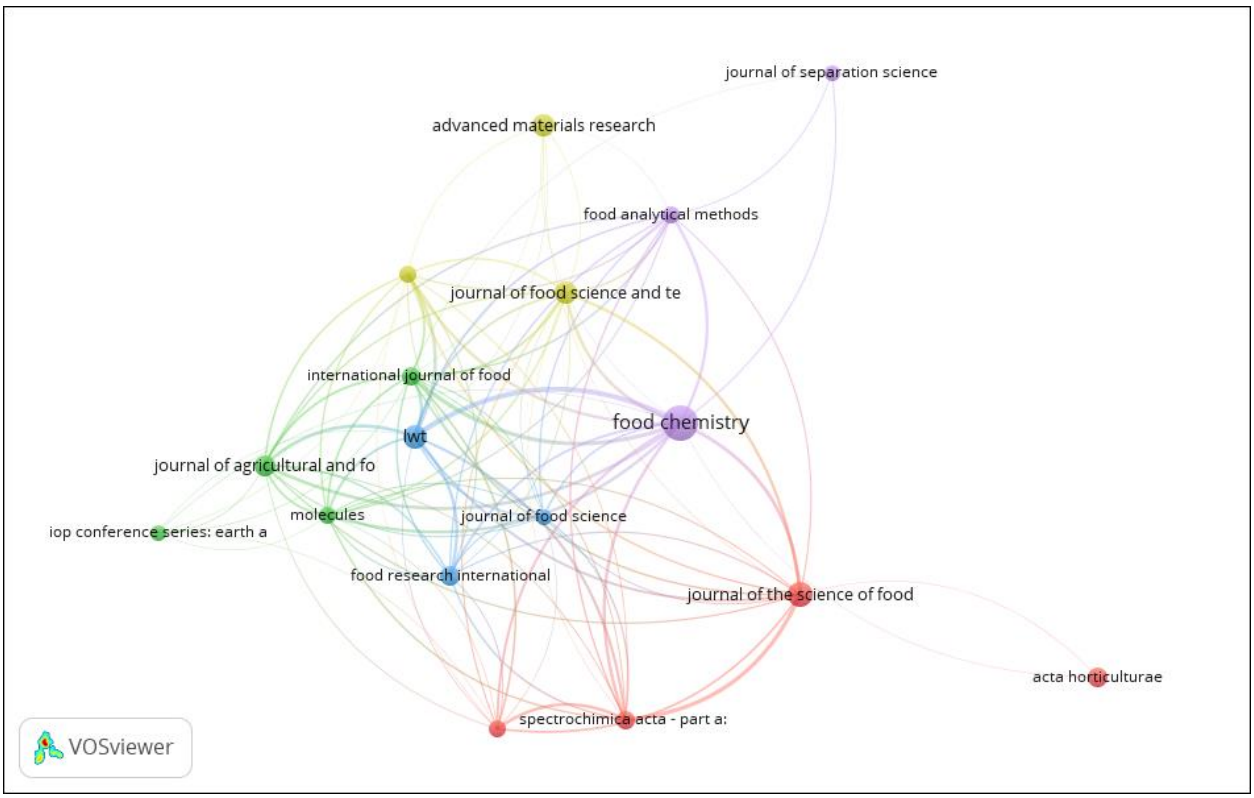

Figure 16: A bibliographic coupling with sources

4. LIMITATION OF THE PRESENT STUDY

For this bibliometric analysis authors have considered only the Scopus database. Other databases like Google scholar, Web of Science are available; but to get complete overview of entire research idea for each research approach; author feel; it is good to go with any one standard repository.

Results given in this survey are only for publications in English language; other languages are excluded as authors of this paper can only understand literature in English and only found it as useful collection, and not on other regional languages specified in the Scopus database.

For VOSviewer software, different thresholds have set and at the visualization descriptions those are mentioned in details. The selection of keywords is according to author's scientific understanding and perception. For tea quality evaluation the publications are limited to duration 2010 to 2021 and for artificial

taste perception of tea the duration is not mentioned as less data found. The secondary data and patent analysis of Scopus database in not under the scope of this survey.

5. CONCLUSION

The survey discovered the facts; tea evaluation irrespective of its huge production quantity; there is least development and publications available comparatively in tea quality evaluation. Scopus database showing incremental trendline for yearly publications for last decade in tea quality evaluation. It indicates day by day the interest of people is growing in this area. China and India these two countries are having comparatively high publication count worldwide, but still the progress in publications on 'artificial taste perception of tea'is not up to the mark. It indicates the complexity and evasion of subject. Future economic growth of any agricultural commodity is only dependent on product uniqueness and progressive difference which can be demonstrated or proved in front of consumer. The relevance of selected tea attributes with keywords shows exact count of publications available with their co-occurrence.The statistical analysis of citations given proves the quality of research utilization.

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